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VOL. XVI. NO. 3.—BOTANICAL GAZETTE.—MAR., 1891.

Black rust of cotton: a preliminary note.[1]

GEO. F. ATKINSON.

Early in the past season I began a study of the fungous diseases of the cotton plant with the special object to determine the disease called "black rust." The first of August, 1890, one hundred circular letters were sent to different farmers of Alabama requesting specimens of "black rust," "red rust," "Frenching," "root rot," etc. As it seemed probable that there was some confusion in the application of these names to certain appearances of the cotton a special request was made of the senders to carefully label the plants with the name applied by them to the disease.

From twenty-five to thirty replies were received including specimens marked "black rust," "red rust," and "root rot."[2]

The disease has been very prevalent and destructive during the season and excellent opportunities were afforded me for studying it in the vicinity of Auburn, not only upon the station farm but on neighboring plantations.

July 22d, on one of my visits to the cotton field, I found the disease had made its appearance in full force in several spots, where fully one-half of the leaves of the plants had fallen off, the remainder being curled, dried, and blackened by a profuse development of dark hyphæ and spores of several fungi, so that by suddenly jarring a leaf the spores would float off in clouds like the smut spores of some of the Ustilagineæ. Some of the plants showed still the earlier stages of the disease, and in other parts of the field were numerous opportunities to study the earlier stages. For two months my time was occupied in noting the external characters, collecting material, examining the different fungi found and noting the relation of each species to the variety of external characters presented in the progress of the disease.

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[1] Paper read before the American Association of Agricultural Colleges and Experiment Stations, Champaign, Ill., Nov., 1890.

[2] The "root rot" disease was reported from only one place. The effects of the disease upon the plant are strikingly similar to those produced by the Texas disease which is caused by *Ozonium* according to Pammel, but due to an entirely different organism, a nematode worm, *Heterodera radicicola*.

The fungi commonly present and which play an important part in the disease are *Cercospora Gossypina* Cooke, a species of *Colletotrichium*,[1] a *Macrosporium*,[2] an *Alternaria*, and frequently a pycnidial stage of some sphæriaceous fungus,[3] and a bacterial organism which produces a characteristic disease of the leaves.

The bacterial disease is often very widely spread even when no evidences of the other fungi are to be found, but is mentioned here because frequently it is an accompaniment of the "black rust" and contributes materially to the aggravation of the disease. It is first manifested by a watery appearance in definite areolate spots which are bounded by the veinlets of the leaf. The spots are sometimes very numerous and frequently conjoined; often the disease follows one or more of the main ribs of the leaf being bounded on each side by an irregularly zigzag line. As the disease ages the spots become blackish and finally brown, frequently then bordered by a blackish color where the disease has extended somewhat centrifugally. The disease hastens the falling off of the leaves.

During the entire season, from July to the close of October, of the thousands of leaves old and young that I have examined, Cercospora Gossypina has been an almost universal accompaniment, and has not been second in point of attack, except perhaps in rare cases. In many cases parallel or immediately succeeding attacks were made by the Colletotrichium. The Macrosporium as a rule follows closely the attack of the Cercospora,[4] indeed sometimes seeming to be the first to attack. In such cases possibly it attacked the spots diseased by Cercospora before the hyphæ and conidia of the latter were developed. The Alternaria usually succeeds the Macrosporium, though often seeming to be parallel with it. By its numerous clusters of hyphæ and profusely developed concate-

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[1] *C. Gossypii* E. A. Southworth.

[2] This seems to be an undescribed species for which I have proposed the name *Macrosporium nigricantium*. The hyphæ are amphigenous, subfasciculate or scattered .050–.140 mm. long × .006–.007 mm. in diameter, nodulose, septate, olive brown. Conidia .018–.022 mm. × .036–.050 mm. strongly constricted about the middle, stoutly rostrate at one side of the apex, smooth, transversely longitudinally and obliquely septate, olive brown. The nodulose hyphæ resemble those of such species as *M. parasiticum* Thuem.

[3] This is probably *Phyllosticta Gossypina* E. & M. Some recent cultures in agar-peptone broth and an infusion of cotton leaves seem to show that it is the pycnidial stage of an undescribed *Pleospora* which I have found on cotton leaves.

[4] Possibly also that of the Phyllosticta.

nate spores in favorable weather the leaf is soon covered with a mass of spores giving a blackened appearance to the leaves.

My correspondents in Alabama use the term "black rust" when the disease progresses very rapidly and the development of the hyphæ of Cercospora and setæ of Colletotrichium, or the Macrosporium and Alternaria spores, is very profuse causing the leaves to appear black. When the disease progresses more slowly, being checked by unfavorable weather, or is in the first stages, the term "red rust" is used. In such cases the Macrosporium or Alternaria has extended centrifugally the spots attacked by the Cercospora, increasing their size, causing them to become more nearly circular, and marking the spots with concentric lines. Also the edges of the leaf are dead and dried, and curled either below or upward, being favorite places for the attack of either the Cercospora or Colletotrichium. The body of the leaf is still green, paled by different shades of a dull yellow or dull purple.

In some cases in the early stages of the disease the Colletotrichium severely attacks the upper part of the stem of the plant and petioles of the leaves giving the stems a dark color from the internal changes, to the leaves a scalded appearance and causing them to shrivel and dry up much as if frost-bitten.

Sometimes the development of Cercospora may be so great and the attack of the other fungi so tardy as to give the appearance of "black rust" produced by it alone. Specimens of this kind were received from one of my correspondents at Eutaw, Ala. The conditions for the development of Cercospora were so favorable that from one-fourth to three-fourths of the leaf surface was covered with a dense mass of the dark brown hyphæ, the remaining portion of the leaf being yellowish with numerous small points of attack. The hyphæ and conidia in such cases are very long, often five to eight times as long as described by Cooke. Specimens collected at a later date at this place gave an abundance of the Macrosporium and Alternaria.

Where other fungi, as Colletotrichium, Macrosporium and Alternaria are abundant, it is often very difficult to find the Cercospora on the leaf. By placing the leaves, freshly gathered, in moist chambers for ten or twelve hours I have never failed to get an abundance of Cercospora, even on the smallest, uppermost leaves of the plant. Sometimes the Macrosporium

is the predominating fungus in the last stages of the disease giving a black appearance to the entire leaf.

Much speculation in agricultural papers has been indulged in regarding the cause of "black rust" of cotton. It is not proposed in this preliminary note to critically examine the various theories propounded. Some of my correspondents who formerly attributed the disease to the peculiar condition of the soil, lack of fertilizers, etc., say that sometimes in the best soil and with careful fertilizing the disease appears in a very destructive form. That has been abundantly proven during the past year under my own observation. Cercospora, Colletotrichium and Phyllosticta are all active parasites, and I am convinced from a year's study that Cercospora Gossypina is a more active and destructive parasite than has been formerly regarded. A diseased condition once started by such a fungus opens the way for the rapid growth and great injury produced by such forms as Macrosporium and Alternaria. It is possible the Macrosporium may infect the leaves unaided by other fungi. Inoculations of plants free from other forms must be made to determine this.

Cercospora Gossypina sometimes produces a serious spot disease of the cotyledons. I first observed this on some young plants started on the horticultural grounds, in September, for experimental purposes. I am told that sometimes in cold seasons in May this spot disease is quite injurious along with "sore shin."

While in North and South Carolina my attention was called to a disease termed "red rust" which was chiefly characterized by a reddening of the leaves not produced nor accompanied by any fungous growth. In most cases this seems to be due to some condition of the soil which induces a hastened maturity of the plant and the development of erythrophyll in the cell sap of the leaves. In some cases the development of erythrophyll is induced by the irritation of mites as I have proved by infection experiments. From several places in both states cotton quite severely injured by mites has been sent me. An account of this was published in Bulletin no. 4 of the South Carolina Agricultural Experiment Station, January, 1889.

The reddening of the leaves by the development of erythrophyll in the cell sap of the leaves is very common in some soils in Alabama and probably in all the cotton-producing states. It is quite possible that all through this belt there

are those who term this the "red rust," but so far as I have been able to learn by talking with farmers in Alabama, and from the specimens received, the term here is applied to the early, or arrested stages of "black rust" as I have described above.

Auburn, Ala.

Flowers and insects. VI.

CHARLES ROBERTSON.

Triosteum perfoliatum L.—In the bud the style is bent and the stigma is pressed against the opposing lobes of the corolla. As soon as the lobes separate the style straightens and the stigma is thrust out. The stigma rises from 3 to 4 mm. above the anthers and appears to be receptive while they are still indehiscent, so I regard the flower as proterogynous. The corolla continues to lengthen until the second stage. In this stage the anthers are dehiscent, and the stigma is turned to one side. The flowers are rather dark purple and collected in inconspicuous clusters in the axils of the perfoliate leaves. Nectar is secreted in a gibbosity in the base of the corolla. The corolla is from 14 to 16 mm. long and is adapted to long-tongued bees.

Visitors: (May 18 and 23) *Apidae:* (1) Bombus Ridingsii Cr. ♀, s.; (2) B. vagans Sm. ♀, s., visited all of the open flowers and forced its proboscis into several buds, whose lobes had hardly begun to loosen, but which contained an abundance of nectar; (3) B. americanorum F. ♀, s.; (4) Anthophora abrupta Say ♂, s,; *Andrenidae:* (6) Augochlora pura Say ♀, s. and c. p., crawls into the tube; (7) Halictus Lerouxii St. Farg. ♀, c. p.

Cephalanthus occidentalis L.—The first peculiarity of the flower that strikes one is the great difference in the height of the anthers and stigma. Indeed, it looks like a long-styled dimorphous flower. The anthers are at the mouth of the tubular corolla, while the stigma rises 7 mm. higher. It looks as if the pollen could never touch the same part of the insect which comes in contact with the stigma. The disparity is accounted for by the fact that the style itself serves to expose pollen to the visitors. In the bud the anthers dehisce, depositing all of

their pollen in a conical mass upon the summit of the style. The style rises to its usual height and holds the pollen where it will easily touch insects lighting upon the globular head of flowers. After the pollen has been removed, the stigma becomes receptive, and the flower is now in the second or female stage.

Meehan[1] has taken the loading of the pollen upon the tip of the style as a plain case of self-fertilization. But it is no more a case of self-fertilization than the loading of pollen upon the style brush of Campanula. As far as they go, Meehan's observations do not support the view that self-fertilization occurs even in absence of insects, for he says: "Numerous seeds are in every head examined. Carefully dissecting one, I found it had 279 flowers, of these 225 perfected seeds, and only 54 failed." He had made the gratuitous assumption that fullness of fruit is evidence of self fertilization.[2] As between cross and self fertilization, the 225 fruitful cases prove nothing; the failure of one in five flowers is presumptive evidence against the power to self-fertilize.

The round heads of white flowers are very attractive to insects. The corolla tubes are 9 mm. long and are very narrow, especially below. The flowers are thus adapted to long and thin tongues. The nectar rises in the tube so that shorter tongued insects can reach some of it, but the predominant visitors are butterflies. On 11 days, between July 5th and August 17th, I observed the following visitors:—

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s., ab.; (2) Bombus virginicus Oliv. ☿, s. and c. p., freq.; (3) B. separatus Cr. ♂♀☿, s., ab.; (4) B. Ridingsii Cr. ♂, s., one; (5) B. americanorum F. ♂♀☿, s. and c. p., ab.; (6) B. pennsylvanicus De Geer, ♀☿, s., freq.; (7) B. scutellaris Cr. ☿, s., one; (8) Emphor bombiformis Cr. ♀, s., one; (9) Xenoglossa pruinosa Say ♂, s.; (10) Melissodes obliqua Say ♀, s.; (11) M. bimaculata St. Farg. ♂, s.; (12) Ceratina dupla Say ♀, s.; (13) Megachile mendica Cr. ♀, c. p.; (14) Nomada texana Cr. ♀, s.; *Andrenidae:* (15) Halictus Lerouxii St. Farg. ♀, s., one; (16) H. ligatus Say ♀, s., one; (17) Agapostemon nigricornis F. ♀, s.; (18) A. radiatus Say ♂, s.; (19) A. texanus Cr. ♀, s.; (20) Prosopis affinis Sm. ♀, f. p.; *Pompilidae:* (21) Priocnemis ful-

[1] Contributions to the Life Histories of Plants. Proc. Acad. Nat. Sci. Phila., 1887, 323-333; 4 figs. See also Bull. Torr. Bot. Club, xv, 54.

[2] Bot. Gazette xiii, 157.

vicornis Cr., s., one; *Scoliidae:* (22) Myzine sexcincta F. s., one.

Lepidoptera —*Rhopalocera:* (23) Papilio philenor L.; (24) P. asterias F., ab.; (25) P. troilus L.; (26) Pieris protodice Bd.-Lec.; (27) P. rapae L.; (28) Colias caesonia Stoll; (29) C. philodice Godt.; (30) Danais archippus F. ab.; (31) Argynnis cybele F.; (32) Phyciodes tharos Dru.; (33) Pyrameis atalanta L., ab.; (34) P. huntera F.; (35) P. cardui L.; (36) Limenitis disippus Godt.; (37) Satyrus alope F.; (38) Thecla humuli Harr.; (39) Chrysophanus thoe Bd.-Lec., ab.; (40) Lycaena pseudargiolus Bd.-Lec.; (41) L. comyntas Godt.; (42) Pamphila zabulon Bd.-Lec.; (43) P. huron Edw.; (44) P. peckius Kby.; (45) P. cernes Bd.-Lec.; (46) P. delaware Edw.; (47) Nisoniades juvenalis F.; (48) Eudamus tityrus F., ab.; *Arctiidae:* (49) Utetheisa bella L.; *Pyralidae:* (50) Scepsis fulvicollis Hübn. — all s.

Diptera — *Conopidae:* (51) Physocephala tibialis Say, s.; *Syrphidae:* (52) Sphaerophoria cylindrica Say, s.; (53) Volucella evecta Walk., s.; (54) Eristalis tenax L., s., ab.; (55) E. latifrons Lw., s. and f. p.; (56) Syritta pipiens L., s.; *Muscidae:* (57) Musca domestica L., f. p.

Coleoptera — *Coccinellidae:* (58) Hippodamea 15-maculata Muls., f. p.; *Scarabacidae:* (59) Trichius piger F., f. p.

Hemiptera — *Lygalidae:* (60) Oncopeltes fasciatus Dall., s.

Lobelia[1] *spicata* Lam. — In my neighborhood this is the earliest blooming Lobelia. The plants are scattered and are neither so attractive to insects nor so easily observed as the next species. The flowers are white and are arranged in rather loose spikes. They are proterandrous, like the other species which have been observed. The corolla tube is 4–6 mm. long, and the nectar is therefore only readily accessible to tongues of medium length.

Visitors: (5 days, May 31 to June 12) Hymenoptera — *Apidae:* (1) Ceratina dupla Say ♀; (2) Megachile brevis Say ♀; (3) Alcidamea producta Cr. ♀.

Lepidoptera — *Rhopalocera:* (4) Pieris protodice Bd.-Lec.; (5) P. rapae L.; (6) Chrysophanus thoe Bd.-Lec.; (7) Ancyloxypha numitor F.; (8) Pamphila peckius Kby.; (9) P. cernes Bd.-Lec. — all s.

Lobelia leptostachys A. DC. — Resembles L. spicata, but the spikes are more conspicuous, and the corolla tubes are a

[1] On the fertilization of Lobelia see Mueller: Fertilization of Flowers, 365, 633.

little longer. On account of later blooming, the list shows less of the genus Melissodes and an increase in Megachile.

Visitors: (7 days, July 8 to 31) Hymenoptera—*Apidae:* (1) Apis mellifica L. ☿, s.; (2) Bombus separatus Cr. ☿, s.; (3) B. americanorum F. ☿, s.; (4) Melissodes obliqua Say ♂, s.; (5) M. bimaculata St. Farg. ♂, s; (6) Ceratina dupla Say ♀, s.; (7) Megachile rufimanus Rob. (MS) ♂, s.; (8) M. brevis Say ☿♀, s. and c. p.; (9) M. petulans Cr. ♂, s.; (10) M. exilis Cr. ♂, s.; (11) Anthidium emarginatum Say ☿♀, s.; (12) Andronicus cylindricus Cr. ♀, s.; (13) Coelioxys 8-dentata Say ♂, s.; *Andrenidae:* (14) Agapostemon nigricornis F. ♀, s.; (15) Augochlora pura Say ☿♀, s., the male sucking through the slit in corolla; (16) Halictus fasciatus Nyl. ♂, s.; (17) H. pilosus Sm. ♀, c. p.

Lepidoptera—*Rhopalocera:* (18) Lycaena comyntas Godt.; (19) Pamphila cernes Bd.-Lec.; (20) Nisoniades juvenalis F.—all s.

Diptera—*Bombylidae:* (21) Systoechus vulgaris Lw., s.

Lobelia syphilitica L.—The large blue flowers are specially adapted to bumble-bees. Delpino saw it visited by Bombus italicus and B. terrestris. In this country Trelease[1] saw it visited by several species of Bombus. As intruders he observed Osmia sp. and Ceratina dupla Say ♀ collecting pollen.

Visitors: (4 days, Aug. 12 to Sept. 3) *Apidae:* (1) Bombus separatus Cr. ♀, s.; (2) B. virginicus Oliv. ☿, s. and c. p.; (3) B. vagans Sm. ☿, s. and c. p.; (4) B. americanorum F. ☿☿, s., ab.; *Andrenidae:* (5) Augochlora pura Say ♀; (6) Halictus connexus Cr. ♀—both collecting pollen which they work out of the anther-tube with their jaws and front feet.

Lepidoptera—*Rhopalocera:* (7) Danais archippus F.; (8) Papilio philenor L.—both s.

Lobelia cardinalis L.—Trelease (*l. c.*) saw this flower visited by humming-birds, Trochilus colubris L. I have never failed to find them about the flowers, and there is no doubt that the flowers are specially adapted to them. The pendant lip shows that the flower is intended to be visited by a bird or insect which is in the habit of sucking the sweets from flowers without resting upon them. I have also seen the flowers visited by Papilio philenor L. and P. troilus L.

On two occasions I counted five individuals of Bombus americanorum F. ☿, about the flowers. Sometimes one of

[1] On the fertilization of several species of Lobelia, Am. Nat. xiii, 427–432.

them would try to reach the nectar in front, but failing, would crawl down to the base of the flower and insert its tongue through the slit, but most of them only tried to reach the nectar through the slit. This is the only time I have seen a bumble-bee obtaining nectar illegitimately.

Augochlora pura and Halictus connexus also visit this plant for pollen, behaving as on the flowers of L. syphilitica.

Since the flowers of Lobelia are intended to be visited by insects entering below the stamen tube it is an imperfection that the tube has openings between the bases of the upper filaments, for this allows improper visitors to steal the nectar through the slits in the upper side of the corolla. Trelease saw Augochlora pura treating flowers of L. erinus in this way and I have observed the same thing in L. leptostachys and L. cardinalis.

Lobelia cardinalis × *syphilitica.*—Very many plants of the two preceding species grew together in a large patch. The ruby-throated humming-bird passed by L. syphilitica and only visited L. cardinalis. The bumble-bees visited L. syphilitica regularly, only stealing the nectar of L. cardinalis in the cases indicated; and they might not have done so, if they had not been drawn among them by L. syphilitica.

The insects which occurred on both species and which effect hybridization are Bombus americanorum, Augochlora pura, Halictus connexus and Papilio philenor.

Among the plants I found nine specimens of the hybrid. The corolla is shorter and broader and the lobes shorter and firmer than in L. cardinalis, and is described by Schneck[1] as of a deep reddish or crimson-purple. There is abundant nectar, but the others seem imperfect.

Twice I saw Bombus americanorum visit the flowers in the regular way, showing that it could reach the nectar easily. This led me to wonder if the humming-bird would visit the hybrid. Seeing one alight upon a limb over my head, I drew back and was rewarded by seeing him come down and visit the hybrid along with L. cardinalis. It was interesting to observe that, while Bombus americanorum could not suck the nectar of L. cardinalis properly and humming-birds did not visit L. syphilitica at all, the nectar of the hybrid was easily accessible to the one and its colors were attractive to the other.

[1] Bot. Gaz. iii, 35.

Campanula Americana L.[1]—In the GAZETTE, xiii, 225, I have observed that this flower is in the first stage of irregularity, and that bees land upon the style and insert their tongues between the bases of the upper stamens. But, although the stigma is turned so as to strike the ventral surface of the bee, the stamens still retain the useless habit of covering the style on all sides with pollen. At first the style is straight so that the bee touches only the upper side, but afterwards it bends so that the bee may touch the sides and even the underside near the tip. But still much pollen is wasted by being fixed on the lower side. Megachile exilis, which visits the flower for pollen, regularly turns and hangs under the style so as to clean the pollen off the lower side. This is another illustration of the fact that in dichogamous flowers, which as a rule are only properly visited for nectar, the pollen often acts disadvantageously by attracting insects which remove it and neglect the flowers in the female stage.

The larger bees, which are the only insects adapted to the flower, visit it only for nectar and only touch the upper side of the style. I repeat the list given in the GAZETTE, l. c., with some additions.

Visitors: (11 days, July 10 to Aug. 28) Hymenoptera—*Apidae:* (1) Apis mellifica L. ☿; (2) Bombus virginicus Oliv. ♂☿; (3) B. separatus Cr. ♂; (4) B. americanorum F. ♂☿; (5) Melissodes bimaculata St. Farg. ♂♀; (6) Megachile brevis Say ♂☿—all sucking; (7) M. exilis Cr. ♂♀, s. and c. p.; *Andrenidae:* (8) Agapostemon radiatus Say ♂♀, s; (9) Augochlora pura Say ♀, c. p.; (10) Halictus Lerouxii St. Farg. ♂, s.; (11) H. coriaceus Sm. ♂♀, s; (12) Prosopis affinis Sm. ♀, f. p.; *Specidae:* (13) Ammophila sp. searching for nectar; *Scoliidae:* (14) Myzine sexcincta F. s.

Lepidoptera—*Rhopalocera:* (15) Pyrameis cardui L. s.; (16) Pholisara hayhurstii Edw., s.

Apocynum[2] *cannabinum* L.—The flowers are white, much smaller than in A. androsæmifolium, and the nectar is lodged in rather shallow receptacles, so that flies and other short-lipped insects can reach it. A. androsæmifolium, according to Ludwig, is visited by butterflies and cements its pollen to their tongues. I have found the pollen-masses of this species on the maxillary and labial palpi of bees, and but

[1] See Barnes. Bot. Gaz. x, 349, pl. x and vol. xi, 99.

[2] On literature of genus see Mueller. Fertilization of Flowers, 396, 631.

rarely on other parts of their tongue. The insects in the list are marked m. l. or t. according as the pollen masses were found on the maxillary or labial palpi, or on the ligula proper.

Visitors: (June 21, 25) Hymenoptera—*Apidæ:* (1) Apis mellifica L. ♀, l.; (2) Coelioxys 8-dentata Say ♂♀; (3) Stelis lateralis Cr. ♀; (4) Nomada articulata Sm. ♂, m. l.; (5) N. incerta Cr. ♀, m. l.; *Andrenidæ:* (6) Macropis steironemæ Rob. (MS) ♂♀; (7) Agapostemon radiatus Say ♀, m.; (8) Augochlora lucidula Sm. ♀; (9) Halictus fasciatus Nyl. ♀; (10) H. connexus Cr. ♂♀; (11) Colletes sp. ♂, m.; (12) Prosopis affinis Sm. ♀; *Eumenidæ:* (13) Odynerus foraminatus Sauss. t.; *Bombecidæ:* (14) Monedula ventralis Say; *Larridæ:* (15) Astata bicolor Say; *Sphecidæ:* (16) Ammophila vulgaris Cr.; (17) Isodontia philadelphica St. Farg., t.; (18) Priononyx thomæ F.; (19) P. atrata St. Farg.

Diptera—*Mycetophilidæ:* (20) Sciara sp.; *Bombylidæ:* (21) Anthrax alternata Say; *Syrphidæ:* (22) Allograpta obliqua Say; (23) Sphærophoria cylindrica Say; (24) Tropidia mamillata Lw.; (25) T. quadrata Say; *Empidæ:* (26) Empis sp.; *Tachinidæ:* (27) Cistogaster divisa Lw.; (28) Ocyptera sp.; (29) Jurinia apicifera Walk.; (30) Micropalpus sp.; (31) Acroglossa hesperidarum Will.; *Sarcophagidæ:* (32) Sarcophaga sp.; *Muscidæ:* (33) Lucilia caesar L.; (34) L. macellaria F.; *Anthomyidæ:* (35) Anthomyia sp.; (36) Limnophora sp.

Lepidoptera—*Rhopalocera:* (37) Argynnis cybele F.; (38) Thecla calanus Hübn.

Coleoptera—*Scarabacidae:* (39) Trichius piger F.

Hemiptera—*Capsidae:* (40) Lygus pratensis L.; *Lygacidae:* (41) Lygæus turcicus F., s.

Carlinville, Ill.

Notes on technique. II.

JAMES ELLIS HUMPHREY.

In the study of zoöspores, especially those of Fungi, it is not always easy to demonstrate clearly the number and attachment of the cilia. The iodine preparations usually recommended for that purpose have not proved satisfactory with me on account of their tendency to shrivel and distort the body of the

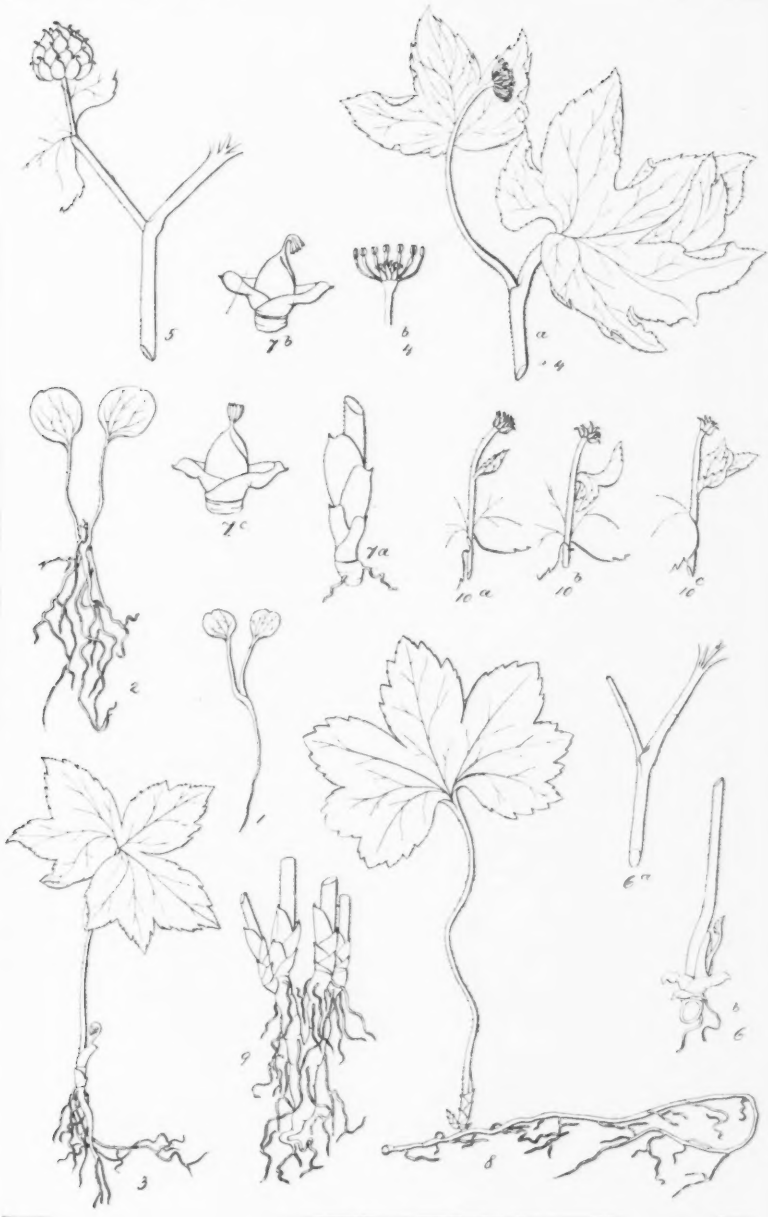
zoöspore. In some cases, too, they have not acted with sufficient promptness to fix the spore at precisely the right instant. In view of these facts attempts have been made to find a more satisfactory method of treatment, and I have adopted after numerous trials a combination somewhat different from any which I have seen suggested, though it involves nothing new in principle.

The zoöspores, in water under a supported cover-glass, are instantly killed by placing at the edge of the cover a couple of drops of a one per cent. solution of osmic acid. This is left for a few minutes to fix the spores thoroughly, which it does without the least distortion, and is then drawn off by means of filter-paper. It is not necessary to wholly remove the acid or to pass water under the cover before applying the staining fluid, which consists of a drop of a moderately strong solution in 90 per cent. alcohol of Hanstein's rosanilin-violet, composed of equal parts of fuchsin and methyl-violet. This stains the cilia and the bodies of the zoöspores of both Algae and Fungi very quickly and deeply, as well as sharply, showing the number and insertion of the cilia as plainly as a drawing, and giving a clear image with the camera lucida.

It is very possible that other stains would serve equally well, but I have not taken time nor has it seemed worth while to seek further in view of the uniformly good results obtained as described. For killing and fixing, I think there is nothing quite so good in all respects as osmic acid.

By means of the above treatment I have had no difficulty in demonstrating the correctness of the statements of Cornu[1] and Hartog[2] that the zoöspores of *Achlya* are ciliate, at least in some cases, when they escape from the zoösporangium, as are those of *Saprolegnia*. This statement is directly opposed to those of other writers and to those of the leading text-books,[3] which state that the zoöspores of *Achlya* escape from the sporangium *without cilia*. My observations were made on a form related closely to *A. polyandra* (perhaps that species), and seem to me entirely conclusive. The discussion of the details of the structure of the zoöspores and of the bearings of the fact stated is reserved for a future occasion; but it

[1] Ann. Sci. Nat. ser. 5, tom. xv, p. 1.
[2] Quart. Journ. Mic. Sci. vol. xxvii, p. 427.
[3] Cf. De Bary: *Vergl. Morphol. u. Biol. d. Pilze*, p. 116, and Engl. transl. p. 108; Zopf: *Die Pilze*, p. 294.



BOWERS on HYDRASTIS.

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may be remarked here, as has been done by the previous writers, that the establishment of the diplanetism of *Achlya* brings it much closer to *Saprolegnia*. Indeed the structural differences between them become reduced to a single one; namely, that while in *Achlya* the sporangia formed from a filament arise after the first one by lateral outgrowth below the basal walls of the previous ones, in *Saprolegnia* they usually arise inside of the preceding ones by the upward growth of the successive basal walls. But I have seen, in an undetermined species of *Saprolegnia*, the formation of secondary sporangia after the *Achlya* type on a few filaments. There remain to be noticed two physiological differences so closely connected as to constitute, perhaps, a single phenomenon. The first swarming period in *Achlya* is reduced to its lowest terms, and at its close the zoöspores become aggregated into a hollow sphere at the mouth of the sporangium, in response to an apparent mutual attraction which Hartog[1] has termed adelphotaxy. Is this mutual attraction the cause of the shortness of the first swarming period?

Amherst, Mass.

A contribution to the life history of Hydrastis Canadensis.

HOMER BOWERS.

(WITH PLATE VIII.)

About ten years ago while engaged in the cultivation of various indigenous plants and the study of their germination and growth some deviations were observed in the behavior of Hydrastis Canadensis so at variance with the accepted view of the life history, that a minute study of all its peculiarities was begun and from that time to the present it has been followed with the view of bringing the facts to the attention of botanists.

My attention was first drawn to the plant specially, on discovering a stage in its growth concerning which no record exists. Afterwards when investigation disclosed that this unknown stage embraces a feature anomalous in the growth of plants, a great incentive for further research was added. This at length brought to light two other important facts

[1] Annals of Botany, vol. ii, no. vi, p. 216.

that seem never to have been noticed, besides several minor points that are unrecorded, together with some slight errors of observation or description. The proper statement of these facts necessitates an account of the life history.

SYNOPSIS OF THE LIFE HISTORY.—Hydrastis Canadensis is a perennial herb found growing in patches in rich open hilly woods, and on the slopes along the wooded bluffs and secondary banks of streams. The seed naturally sown after the ripening of the fruit in July or August, does not germinate until the following spring, about the last week in April, or the first in May. The plantlet consists of a pair of orbicular cotyledons on long spreading petioles, joined to a slender radicle, and makes no further advance in growth the first year of its life, other than the development of the cotyledons, together with the attached radicle, surmounted by a large bud. The seed-leaves alone do duty for foliage during the whole growing period of this stage of its existence.[1]

The second year it sends up a single rounded, palmately-lobed leaf on a footstalk articulated at the root. This stage often persists through the third year; the plant then sends up a larger radical leaf, with perhaps one or more smaller ones in addition.

The third or fourth year the stem arises 15 to 30 or more cm. high, having two alternate leaves, with two-ranked arrangement, the lower larger and petioled, the upper sessile at the junction of the peduncle of the flower with the stem of the plant.

It has thus three stages of growth, being acaulescent for two or more years, and bearing fruit the third or fourth year. The bud-scales found at the base of the stem are two-ranked, conduplicate, and equitant. Under certain conditions it propagates itself by adventitious buds from fibrous roots. There are also evident stipules.

DETAILED DESCRIPTION. —*First stage, duration one year.*— The cotyledons on first appearing are bright emerald green, glossy, oval, about 5 mm. broad and 6 mm. long. The petioles are long and somewhat thickened; the radicle long and slender. The cotyledons attain their full size in about three

[1] Rarely, in a very vigorous seedling, a small radical leaf on a short footstalk will be sent up late in June or early in July, and also in a few instances where seedlings have been transplanted at an early stage to a more favorable location, a small radical leaf has been observed to spring up.

weeks, when they measure 8 to 12 mm. in diameter. In general outline they are now orbicular, and slightly emarginate, with three basal nerves, well defined on the under surface, and of a dull green color. The petioles are now long, slender, slightly pubescent, somewhat divergent, and joined to the radicle 6 to 12 mm. below the surface.

In August or September, after the first stage of growth has been completed, the plant consists of the following parts: A few fibrous roots at irregular intervals along a thickened and tapering radicle, from the summit of which a small yellow bud arises about 4 mm. in height; and the two foliaceous cotyledons, showing evidence of maturity and decline, with their petioles inserted at its base.

Second stage, duration one or two years.—The rootstock is small, erect, somewhat conical, and continuous with what constituted the radicle of the first year, which gives off several fibrous roots. There is no stem as yet, and the single leaf is round-cordate, sometimes partially peltate, palmately five-lobed, doubly serrate, with a cup-like depression at base, sits horizontally on a footstalk 5 to 15 cm. long that is articulated on the rootstalk, and has evident stipules.

Third stage, duration indefinite.—The rhizome is knotty, variously contorted, erect, with many long fibrous roots of a bright orange color. The stem arises from a terminal bud 15 to 30 cm. or more high, 4 to 6 mm. in diameter, erect, round, more or less pubescent, yellow below the surface, becoming purplish from the point of exposure to light a short distance upward. Three and sometimes four bud-scales embrace the base of the stem, the inner much the largest. They are conduplicate, equitant, strongly keeled, hooded, mucronate, 10 to 15-nerved, the lateral margins membranaceous. They arise from nodes 4 to 6 mm. apart, and are yellow, becoming purplish if exposed at the surface, and are homologous with stipules. The leaves are now two, rarely three, alternate, with two-ranked arrangement, and plicate vernation. The lower leaf is the larger, 15 to 30 cm. in lateral diameter when mature, with five acute ovate-lanceolate lobes well-defined by deep incisions. The sinuses are always well rounded at the bottom, never acute, though often narrow; the lobes mostly overlap each other and two lateral ones bear one or more minor lobes on their lower borders. The general outline is between reniform and cordate; the basal sinus is very narrow,

the margins often overlap to some extent and occasionally unite for a short distance, thus making the leaf partially peltate.

In all cases a cup-like depression exists at the insertion of the leaf-blade. The petiole is 2.5 to 7.5cm. long, roundish, thick, swelling at the base and amplexicaul, with small tubercular stipules visible at an early age. The petiole and stem both diverge at their point of junction, giving the appearance of a bifurcate stem. The upper leaf is smaller, sessile at the junction of the peduncle of the flower with the stem, and partly clasping. The absence of the leaf-stalk in the smaller, combined with the angle of insertion of both blades, causes the leaves to occupy the same horizontal plane. The third leaf, when present, is much smaller, often distorted, always sessile on the peduncle, and possibly should be regarded as a bract. The flower is white, with a diameter of 12 to 18 mm., solitary, erect, terminal, on a peduncle 12 to 25 mm. long, with 3 or 4 orbicular, concave, green or purplish, caducous sepals, and no petals.

The stamens are 50 to 75, spreading, curving outward and upward, the pure white filaments gradually dilated from the base outward and somewhat contracted near the summit. The anthers are pale straw-color, adnate, with lateral longitudinal dehiscence. The 10 to 20 or more pistils are in a head, with white flat broadly two-lipped stigmas, the lips thin, rounded, and wavy-margined. The style is straw-colored, short and thick, being simply a contraction of the upper part of the ovary. The olive-green oval ovary is somewhat gibbous, sparingly pubescent, sulcate along the whole ventral aspect and the upper third of the dorsal, 1-celled and 2-ovuled. The red fruit resembles a raspberry and ripens in July or August. It consists of an aggregation of fleshy carpels, forming a globular head, each carpel bearing at summit the persistent style which is strongly inclines toward its dorsal aspect. The one or two seeds are small, about 2 by 3 mm. ovoid, black, hard and polished, anatropous, pendulous, with ventral rhaphe, fleshy albumen, and minute embryo.

GENERAL OBSERVATIONS.—The anomalous behavior of this plant in its first stage of growth has escaped observation, partly, I suppose, on account of its retiring habits. It always grows in patches in secluded and shady spots, where the earth is carpeted with decaying leaves; often beside rotting logs, where

the roots are mulched by the decaying wood. The seed-leaves being small and often lying almost flat on the surface, would be observed only by chance; even then there would be nothing in their appearance to connect them with the plant under consideration, unless removed from the earth, when the root by its bright yellow color might indicate the relationship to Hydrastis.

In germination the cotyledons often arise from the earth separated by an interval of 2mm. or more and sometimes one cotyledon will show itself a day or so before the other one appears. If from any cause the cotyledons are destroyed early in summer the lemon-tinted bud does not grow until the following spring. Usually four different kinds of buds are found on an old plant, viz. large winter buds of two kinds, terminal and axillary; small latent buds, with scales but slightly developed; and adventitious buds that are formed on root fibers under certain conditions.

The winter buds of Hydrastis are large and deserving of special study, not only as illustrating the perfect protection that is so often provided for the tender parts during hibernation, but also as furnishing an excellent example in the morphology of leaves, the scales being homologous with stipules. The terminal bud is the largest, and developes the fruiting stem. The axillary bud produces a radical leaf; or, as often occurs, remains dormant for a time. The arrangement of the scales of a terminal bud at the close of the growing season, when the plant has fully completed the preparation for its period of rest, is such that but one, the outer, is truly equitant, the others, each in turn, completely overlapping and enfolding by their hooded and membranaceous expansions the inner till the young shoot itself is enshrouded by the last one.

On removing the scales at this period the young shoot is found to be large; the plicate foldings of the leaves are easily discovered, but the flower-bud is larger than all the rest, the stem being merely a conical eminence upon which the other parts sit. Yet the stipulate amplexicaul base of the petiole is visible, joined to the leaf, seemingly without the intervention of a leafstalk. The sessile leaf is very small indeed, entirely overshadowed by the comparatively enormous flower-bud whose sepals can easily be counted, and the stamens plainly observed.

Stipuliform appendages are not a feature of the order *Ranun-*

culaceæ, but Hydrastis has evident stipules, to be seen in the small tubercles, or points, projecting backward and upward from the amplexicaul petiole of the lower leaf of a fertile stem; and more plainly still at the base of the footstalk of a radical leaf, where they will be found, in early summer, incurved or overlapping each other and always enshrouded by the accompanying bud-scale. Later, when growth has ceased and the old bud-scales have decayed, there will be found, emerging from the overlapping stipules of a radical leaf, an abortive leaf on a short and rudimentary petiole, with a fully developed stipulate base, which enwraps another smaller one, and so on till the full complement necessary to the formation of a hibernaculum is present. Then, when the old radical leaf has served its time and is overtaken by decay there will be seen, for a short time, tipping the outer scales of the hibernaculum which sprung from its axil, instead of a mucronation, the depauperate leaf raised on a short and tapering footstalk but a few millimeters in height. Sometimes the depauperate leaf appears surmounting the inner scales of a terminal, or the outer scales of an axillary bud, as a digitate or merely fimbriate attachment without the intervention of a foot stalk. This soon perishes, and nothing will be found, after the bud-scale has expanded in the spring, but the blackened mucro, the remains of the footstalk of a depauperate radical leaf, thus plainly demonstrating that the winter bud-scales of Hydrastis are the homologues of stipules.

The development of a radical leaf without an offshoot, or caudex, from a bud in the axil of the lower bud-scale of a fertile stem of the same season's growth often occurs. The planes of insertion of the scales of a new bud are always at right-angles to the plane of the one from whose axil it sprung. Buds are formed in increasing numbers as each year passes, until as many as 20, or, even to 60 fertile stems may be found arising from one rhizome of from six to ten years age, together with a greatly varying number of sterile stems, or radical leaves, ranging from none at all in some cases, to perhaps twenty in others. Among almost every cluster from an old rootstock there will be found one or more stems bearing three leaves. After the annual decay of the stem there is left a cup-like depression at the summit of the caudex.

The persistence of these depressions, each for a few seasons, has given the plant one of its common names "golden

seal." The rootstock is not horizontal, as represented in the drawings of all who have described the plant previously, and if ever found so it is an accident of growth, as I shall proceed to show. Development of rhizome begins with the second year, by the gradual thickening of the head of the primary fibrous root, or radicle. It is difficult to determine at this stage just where the rhizome ends and the root begins. The hibernacula are produced, after the second year, from short offshoots which spring from the axils of previous bud-scales, the offshoots being of such length only as to permit the bud to assume the erect position. The contortion or contraction produced in the rhizome by the decay of some of the offshoots each year is almost always in such manner as to cause the hibernacula to assume a more erect position, one in fact almost continuous with the older part of the rootstock. Thus a perpendicular axis is generally maintained. From this habit of growth an old rhizome is a knotty subdivided mass and presents no regularity of outline. The young rhizome, and the offshoots of the older ones, are marked by slight annular ridges, the sites of former bud-scales. It seems to be a law of development with this plant, that two or more years are required for the perfecting of a terminal bud and its supporting caudex. An old rootstock is abundantly supplied with fibrous roots. These, from their manner of growth and other characteristics, are found to be of two kinds, unequally apportioned. Those most numerous incline downward in their growth and have a length varying from 10 to 20 cm. the others are few in number, and larger, each measuring 20 to 50 cm. or more in length, with a diameter of 1 to 1.5 mm. and growing in a horizontal direction at a depth of 2.5 to 5 cm.

These large fibers under certain conditions sparingly produce adventitious buds, from each of which one or more small radical leaves arise on footstalks. These leaves are identical with the foliage of the second stage of growth from the seed. Three of these buds have been observed on a single large fiber at intervals of 7.5 cm. or more. They seemed to be formed only on those fibers that have been severed from the rootstock without greatly disturbing their distal extremities. Adventitious buds may occur upon the large fibers while yet attached to the rhizome, but if such is the case I have never yet observed it, the budding fiber always being found detached from the plant, with the proximal extremity blackened for a short

distance by incipient decay. Young plants have not been observed to produce budding roots. The leaves have five lobes. Many books give seven, but all over five are as a rule minor lobes whose ribs spring, posteriorly, from the two inferior basal veins. The veins are very prominent on the lower surface and there is a considerable linear depression on the upper surface, in their track. This gives the leaf at the time of flowering, when it is but slightly developed, a very rugose appearance, which persists for some time. The plant puts forth very early, and before the forest is fully clothed in leaves it has attained almost its full development in all points save the expansion and ripening of the fruit, and the maturing of its underground structures. This energy for the first few days is mostly expended in the growth of the stem, which arches over and bends itself as it is extended from the caudex, bursting asunder the bud-scales, which have begun to enlarge rapidly, the inner one especially developing beyond the others. The stem, thus bent, emerges from the earth often 5 cm. or more before the top is dragged forth. Sometimes it happens, when the ground is hard and dry, that it fails to extricate itself, and therefore perishes. The leaves are but slightly developed when the flower appears, which occurs almost immediately after the stem assumes the erect position. The flower lasts five or six days. In a dry season the plant dies down soon after the ripening of the fruit, and by late September the top has disappeared. Again when the season is more moist it will persist even to the beginning of winter.

The fruit when ripe is readily detached from the stem, and has a shallow depression at its base. It is insipid to the taste, non-poisonous, and is eaten by birds, by which means the seeds are disseminated. From various causes but few of the seeds naturally sown ever germinate, and the extension by adventitious buds forming on the root fibers is very slow, as this mode of propagation does not seem to be as well established with this plant as it is with some others.

It would seem from present indications, that the time when Hydrastis will be no longer found in our forests is almost at hand. Possibly its total extinction could never have occurred from the settling and clearing up of the country only, since the natural terraces of many inaccessible ravines, bluffs and mountain sides, where the material best suited for its sustenance had accumulated for centuries, would have been its

impregnable strongholds. But the drafts made upon it in pharmacy to supply the growing demand of the medical profession have set upon it that impecunious class, the "sang" and "puccoon" diggers, who have almost exterminated it in many of those regions where it grew in great abundance.

It may yet be found from the Mississippi river to the Alleghenies, as far north as Canada and to Tennessee on the south, with a limited area of distribution beyond the Mississippi, in Missouri and Arkansas[1]. Over most of this territory it is now so thinned out that its collection is not the commercial success it formerly was. The above boundaries very nearly mark the extent of the distribution it had attained on the earth's surface in its most flourishing time.

But, in this region of central Indiana, within the area of its former natural abundance, I have demonstrated by experiments of some years' duration, that it can be successfully grown by giving it as far as possible the surroundings that it had in the pioneer days of the country. It endures close association with but few other herbs, yet the shade afforded by many of the shrubs and forest trees, if not too dense, seems to be a requirement essential to its perfect growth and development. The grasses are its deadly enemies, and ground that is trodden will not support it. Under such conditions it quickly perishes. A single large plant, removed from the woods to a suitable situation, I have observed in several instances to spread so that an area of five or six feet in diameter would be occupied in eight or ten years time, without any artificial aid, save the keeping in subjection of all other encroaching plants.

Individual characteristics are noted, as marking with more or less variation each group or patch of plants, indicating, that though Hydrastis is a recluse among plants, and presents some deviations that are remarkable, yet this one feature which it possesses in common with most representatives of the vegetable kingdom, may lead through judicious selection and the careful study of its habits of growth, to the establishment, in time, of new varieties. This possibility the following observations of three district patches, originating from plants obtained from different points, and grown on my grounds, seem to show:

[1] Lloyd's Drugs and Medicines of North America, vol. I, no. 3, pl. IX.

Patch no. 1, short: stems 15 to 20 cm.: peduncle short, 6 to 12 mm.: fruit almost sessile on some; carpels 12 to 18: leaves rugose, much incised resulting in many minor lobes, though but five basal veins: color of stems mostly green, slightly purple at base.

Patch no. 2, medium: stems 25 to 30 cm., purplish from base $\frac{1}{3}$ of height: peduncles 18 to 25 mm.: carpels few: leaves coarsely serrate, minor lobes rare, scarcely pubescent, large, many of them 30 cm. across.

Patch no. 3, tall: stems 30 to 37.5 cm. purplish from base $\frac{2}{3}$ of height: peduncles 35 mm.: carpels 25 to 30: leaves slightly rugose, lateral diameter of lower leaves 25 to 30 cm., minutely pubescent.

New Ross, Indiana.

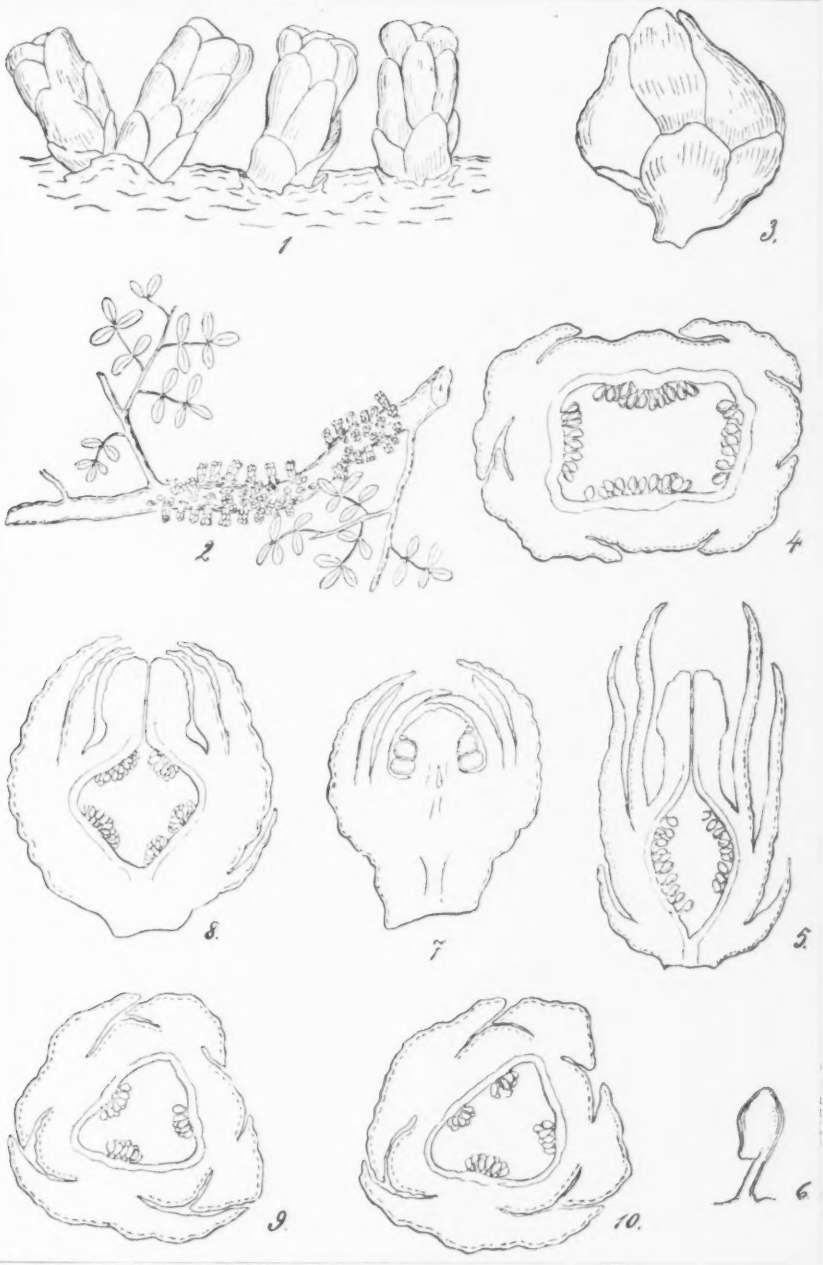
EXPLANATION OF PLATE VIII.—Fig. 1, seedling 2 or 3 days after germination. Fig. 2, seedling at the end of the first season's growth. Fig. 3, second year from the seed. Fig. 4, *a*, top of flowering plant early in May, stipular eminences plainly shown at base of lower leaf; *b*, flower with most of the stamens removed. Fig. 5, part of stem with fruit, late in July. Fig. 6, stipules; *a*, part of fertile stem with amplexicaul petiole of lower leaf, showing tubercular stipules; *b*, caudex with portion of radical leaf petiole, old bud-scales dissected back and showing stipules at base enveloping the rudimentary hibernaculum, depauperate leaf protruding, as observed in June. Fig. 7, stipules as bud-scales; *a*, bud-scales at base of fertile stem, early in May; *b* and *c*, buds formed in the axil of a radical leaf, as they appear in October or November, with outer scales dissected back; *b*, one of the bud-scales surmounted by a depauperate leaf; *c*, same with merely fimbriate attachment. Fig. 8, horizontal root fiber, with adventitious bud and radical leaf. Fig. 9, rhizome with most of the fibrous roots removed, showing perpendicular character of axis. Fig. 10 series showing transition from floral bract to leaf, as sometimes observed in exceptional cases where third leaves are produced; *a*, part of upper portion of stem showing attachment of sessile leaf, floral bract, and fruit soon after anthesis; *b* and *c*, same with bracts more leaf-like.

Two undescribed species of Apodanthes.

B. L. ROBINSON.

(WITH PLATE IX.)

It is now more than twenty-five years since the discovery, in western Arizona, of *Pilostyles Thurberi* Gray, a diminutive parasite which, notwithstanding great disparity in size, is nearly related to the famous Rafflesia of India. Although the genus Pilostyles, or more correctly, Apodanthes § Pilostyles, is well represented in South America, the rare A. Thur-



ROBINSON on APODANTHES

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beri has until lately been its only known North American species. Among the many discoveries made by Mr. C. G. Pringle, however, two new members from northern Mexico have been added to the genus; and specimens of these interesting plants (nos. 1949, and 1950 of Pringle's *Plantae Mexicanae*) have recently been distributed as *Apodanthes Pringlei* Watson, and *A. globosa* Watson. Owing to the diminutive size of the plants in question, their study entailed methods not generally necessary in the systematic examination of phanerogams, and the publication of descriptions of the new species has been much delayed. At the suggestion of Dr. Watson, however, the writer has lately made a microscopic examination of the material in the Gray Herbarium, and presents, as a result, the following descriptions, which are as full as the limited stages of development represented permit.

Apodanthes Pringlei Watson. — Flowers densely crowded cylindric, becoming ovoid, one and one-half lines long, aromatic; bracts and divisions of the floral envelope twelve to fifteen, erect, very unequal in length, imbricated in three (or four) obscurely defined series, ovate to oblong, obtuse, entire or minutely erose, dull brown, the innermost yellowish at the ends: ovary inferior or nearly so, usually quadrangular in cross-section, and with four distinct though rather broad placentæ; style well developed, fully half as long as the ovary; stigma ovoid, umbonate on the slightly produced non-stigmatic apex; fruit broadly ovoid, two lines long, one and one-half lines in diameter, covered with the closely appressed bracts: staminate flowers unknown. —Occurs upon small woody branches of *Dalea frutescens* Gray; collected by C. G. Pringle in the Sierra Madre near Monterey, June 27, 1888.

The placentation of this species shows more or less variability, not only in different flowers, but even at different heights in the same ovary. In most cases a cross-section directed through the middle of the ovary shows (as in fig. 4) the placentæ in a regular relation to the surrounding bracts. In other instances, however, no such correspondence is apparent, and the placentæ are not even symmetrical in relation to each other.

Apodanthes globosa Watson. — Expanded flowers and fruit unknown: buds scattered, globose, two-thirds to one line in diameter; bracts and divisions of the floral envelope eleven to

thirteen, subequal, in three distinct decussate series, broadly ovate to orbicular, minutely erose, thickish, transversely roughened on the outer surface, very dark and shining purple: in the staminate flowers the anthers about thirty, globose, sessile, borne in two crowded rows upon the shaft of the staminal column, of which the upper expanded portion is convex, and minutely papillose over its entire surface, the papillae upon the edges being slightly more prominent; a rudimentary ovary (?) is represented by a narrow central cavity in the base of the column: in the pistillate flowers ovary inferior, three to four angled, but with no regular placentæ, the ovules being distributed in small isolated groups over the entire inner surface; style scarcely any, the stigma large, hemispherical, umbonate.—Occurs on small branches of *Bauhinia lunarioides* Gray; collected by C. G. Pringle in the Sierra Madre near Monterey, June 30, 1888.

This species considerably resembles in size and form *A. Blanchetii* Gard. of Brazil, also parasitic on a Bauhinia. In the latter, however, the bracts are described as fimbriate-ciliate on the margins, while in A. globosa they are at most minutely erose. Furthermore the ovules of A. Blanchetii, according to Sir Joseph Hooker,[1] are crowded over the whole surface of the ovary, while in A. globosa they occur in rather small isolated groups. The single staminate flower of A. globosa, which was found in the material investigated, occurred upon the same branch with many pistillate flowers. Although a considerable number of flowers of A. Pringlei were examined, all proved to be fertile. The "thallus" of A. Pringlei, investigated by cutting sections of the infested branches of Dalea, appears at the time of flowering to consist of dense, isolated, more or less wedge-formed masses of tissue, extending not only through the cortex but to a considerable depth along the medullary rays into the woody tissue of the host.

Cambridge, Mass., Nov., 1890.

EXPLANATION OF PLATE IX.—*Apodanthes Pringlei* Watson.—Fig. 2 represents the habit of the parasite as it occurs upon the host plant; fig. 1, flowers; fig. 3, fruit; fig. 4, cross-section of the flower, showing the usual placentation; fig. 5, median longitudinal section of the flower; fig. 6, ovule. All the drawings except fig. 2 are considerably magnified.

Apodanthes globosa Watson.—Fig. 7, longitudinal section of a staminate flower; fig. 8, the same of a pistillate flower; figs. 9 and 10, successive (rather thick) cross-sections, showing the varying placentation at different heights in the ovary. This may also be clearly seen in the longitudinal section, fig. 8.

[1] In De Candolle's *Prodromus*, vol. xvii, p. 115.

BRIEFER ARTICLES.

Erythræa Pringleana Wittr. nov. spec.— Planta annua, subparva, 8–21 cm. alta, paullulum ramosa, glabra; foliis omnibus brevioribus quam internodiis; foliis infimis non rosulatis, ovatis apice acutato, brevissime pedunculatis, minimis, 2–3 mm. longis; foliis inferioribus lanceolatis, 3–6 mm. longis; foliis mediis et superioribus lineari-subulatis, 6–15 mm. longis; floribus longe pedunculatis, pedunculis plerumque longioribus quam floribus; sepalis eadem fere longitudine vel paullo longioribus quam tubo corollæ; hoc tertia fere parte breviore quam laciniis limbi; his 7–10 mm. (plerumque 8 mm.) longis, ovatis apice paullulum crenulato; corolla emarcida laciniis limbi contortis persistente, fructus includente; antheris staminum brevioribus quam filamentis; germine eadem fere longitudine vel paullulo longiore quam stylo stigmateque.

Mexico: in collibus prope Guadalajara 18/9–88 legit cl. *C. G. Pringle*, (no. 2595).

Haud impossibile mihi videtur hanc speciem cum *Erythræa tenuifolia* Martens et Galeotti, anno 1844, ad exemplaria prope Guadalajara lecta, manco in modo descripta, identicam esse. Nomen specificum "tenuifolia" tamen secundum legem prioritatis non est retinendum, quia cl. *Grisebach* Erythræam alteram (e Hungaria et Gallia) jam anno 1839 sub hoc nomine descripsit.— VEIT WITTROCK, *Stockholmia* mense Januarii 1891.

[It may be well enough to state in this connection that what was distributed as "*Microcala* n. sp." (no. 2598) is *Schultesia Mexicana* Watson, n. sp., soon to be published.—C. G. PRINGLE.]

New species of Montana fungi (with plate X).— The illustrations of two new species of Montana fungi described last month, p. 47, were received after the number was in press. At the authors' request they are now published with the accompanying

EXPLANATION OF PLATE X.—*Sporidesmium sorisporioides* Ellis & Anders. 8, fungus about natural size on dead wood of Populus tremuloides; 9, small mass of spores superimposed on the hyaline, semiamorphous mycelium, from the swelling up and internal division of the elongate ends of which the spore-masses are developed; 10, two mature spore-masses, *A* having become quite free from the mycelium.

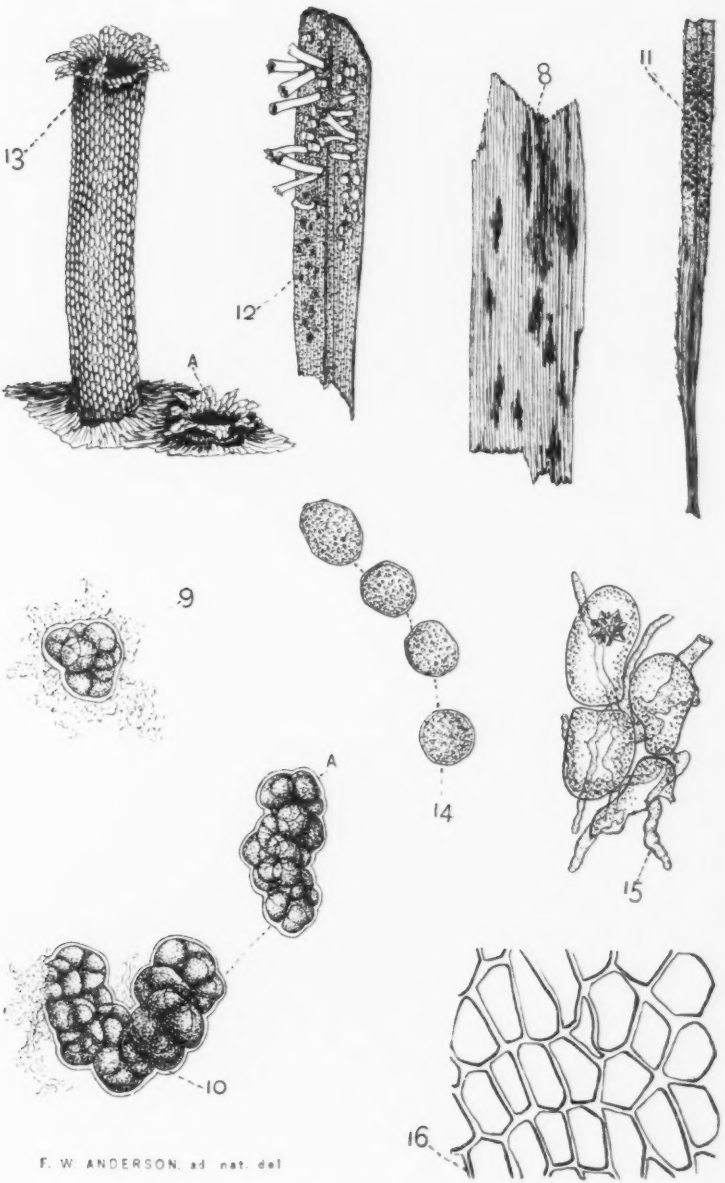
Aecidium Liatridis Ellis & Anders. 11, portion of leaf of Liatris punctata about natural size showing a patch of the fungus; 12, a small patch considerably magnified; 13, a perfect tube (cup) more highly magnified. At *A* is shown a cup that has gradually broken down to almost the surface of leaf; 14, four spores; 15, several cells of host

tissue showing the mycelial threads of the aecidium which permeate the leaf tissue in all parts of the affected spots; 16, a few of the pseudoperidial cells highly magnified to show their true shape.

EDITORIAL.

One of the hard questions that working botanists are called upon to answer, especially those who are also concerned in training botanists, is "what original work shall I do?" The background of the question usually contains no literature and no appliances other than a few standard botanical works and a microscope. There seems to be a widespread notion that when one comes into the possession of a compound microscope he is equipped for "original work." The lack of literature and collections precludes the recommendation of any systematic work. The general lack of knowledge as to the ease with which certain important physiological phenomena can be observed, usually excludes any such answer to the question. Besides, the applicant for "original work" expects that it will involve doing something with his microscope. Nine times out of ten the advice will be given to study the minute anatomy of some plant, as the easiest thing to do. Naturally this is the expected advice, and sectioning and drawing begin at once. But the proper study of the minute anatomy of any plant is far from being "the easiest thing to do," and to recommend any such study to one who has not been thoroughly trained by a competent instructor, is to make a great blunder.

In the first place, the ability to correctly interpret is not in the possession of any tyro who can cut a section or focus a microscope. There are more optical illusions due to the microscope than to anything else, and it is chiefly these illusions that will be drawn and reported when difficult, and hence interesting, structures are being investigated by an untrained observer. The unrecognized hiatuses in what appears in the field of the microscope may be small enough when measured by the metric system, but they may be of infinite importance in the interpretation of structures. Such work can only be done by the most careful and reiterated labor of a trained observer. Of course all this only applies to cases where publication is contemplated, for any amount of valuable information may be obtained in a very pleasant way by any one who is doing such work merely for his own edification. But when work rises to the dignity of being called "original investigation," it is proper that it be hedged about by a full knowledge of its real difficulties.



ELLIS & ANDERSON on NEW SPECIES OF MONTANA FUNGI.

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In the second place, the claim that no library is needed for such work, and that all that one needs is a microscope, is a mischievously false notion. It is far easier to-day to command a literature that will enable one to do some systematic work upon the flora of North America, than one which will enable an anatomist to properly discuss an anatomical subject. The absence of references to literature (and by this is not meant foot-note references) in such investigation leaves the work "in the air." It is like shooting with a shotgun in the general direction of the game in the hope of hitting something. If the investigator is not prepared to say what he has found that is new, no one else is apt to take the trouble to do it for him. The sooner we can get rid of the notion that a microscope is a magic instrument, which when touched transforms one into an original investigator, the better. It is just as magical as a hand-saw, of which tool one may possess a chest-full, and yet not be a carpenter.

CURRENT LITERATURE.

The grasses of dry climates.[1]

The author of this paper calls attention to some hitherto unknown peculiarities in the grasses of dry climates, among them being the singular development of the lowest internodes of the culms, shoots and basal leaves. He considers these characters just as important as the interior structure of the leaves for adaptation to a dry climate. He distinguishes: 1. tuberous and bulbous grasses; and 2. tunic-grasses. Tuberous grasses are such as *Phleum pratense* var. *nodosum* Gaud. and *Arrhenatherum avenaceum* var. *nodosum* (*Avena nodosa* L.), of which one or more of the basal internodes of the culm and shoots attain a tuberous development, while *Poa bulbosa* L. represents a bulbous grass, since here the bases of some of the sheaths of the leaves have increased in thickness and form a bulb very much like that of an Allium. The tuberous grasses are relatively rare in comparison with those whose culms are not thickened, a circumstance which has led to their being ranked as mere varieties. Such forms are especially prevalent in the Mediterranean countries. The same is also the case with Poa bulbosa, which occurs more commonly in these countries than further north. Besides the above mentioned, are the tuberous

[1] E. Hackel. — Ueber einige Eigenthuemlichkeiten der Græser trockener Klimate. — Verhandlungen der k. k. zool.-botan. Gesellsch. Wien, Jahrgang 1890, pp. 125–138.

Alopecurus bulbosus L. and the bulbous *Festuca spadicea* L., the only ones of this group which occur in Middle-Europe.

The author, has, however, observed similar forms to be abundant and more characteristic of other parts of the world. Those he enumerates from our own country are as follows: From California and the Western States the tuberous *Melica bulbosa* Gev., *Californica* Scribn., *spectabilis* Scribn., *fugax* Bol., *bromoides* Gray and *subulata* Scribn., *Beckmannia eruciformis* Host. and finally from Mexico the tuberous *Panicum bulbosum* Kth., *scaberrimum* Lag. and *Torreyi* Tourn.

These tuberous and bulbous forms only occur in countries with periodical dry seasons, and none have been observed in the moist parts of the tropical region. It is very interesting to learn that the author does not consider these tubers or bulbs as reservoirs of starch or sugar, as are the similar organs of Liliaceæ, Iridaceæ, etc. Though they are structurally homologous with these, physiologically they are water-reservoirs. The author has shown that Poa bulbosa on being cultivated in moist soil almost lost its bulbous character.

The second group, *Gramina tunicata*, includes forms in which the base of the culms and shoots are covered with at least three faded sheaths. These all inhabit dry localities. In those forms which prefer damp or shaded places, there is usually but one faded sheath present and even that disappears very soon. The typical tunic-grasses are especially characteristic of the Mediterranean region, and besides the tuberous and bulbous forms, all the other perennial Mediterranean species belong undoubtedly to this group. The author distinguishes between straw- and fiber-tunics; in the former the sheaths remain complete, although faded, in the latter the sheaths break up into fibers. Of these two groups the fiber-tunics are characteristic of the Mediterranean region, while the straw-tunics occur in all the other countries with similar climate. Some forms from Australia, Capland, India, Brazil and North America show the development of wool or felt on the sheaths, as for instance *Eragrostis eriopoda*, *Danthonia lanata*, *Bouteloua eriopoda* and others, representing wool- and felt-tunics. The function of these different tunic structures is undoubtedly to serve as reservoirs of water, as has been proved experimentally in the case of Koeleria setacea and a variety of Andropogon contortus. The author of this interesting paper calls the attention of botanists for further studies upon this subject.—Theo. Holm.

Minor Notices.

Mr. A. S. Hitchcock, of the Shaw School of Botany, has just published a catalogue of the vascular plants in the vicinity of Ames, Iowa. It is no. 7 of the contributions from the Shaw School. The

list is based upon collections made during the years 1882 to 1889, and shows very careful work. Specialists have been consulted in their various groups, and the nomenclature follows the use of the oldest specific name in every case, accompanied by many useful citations of authorities.

THE LAST number of *Pittonia* is before us (vol. ii, part 9) and we note the following contents: In a discussion of the genus Actæa, Prof. Greene doubts whether we have the true Old World A. spicata with us at all, and is also confident that we have 3 or 4 species of our own. He characterizes a new species from Arizona. Ranunculus ellipticus is a new species to replace much that has been called R. glaberrimus. A very useful feature of this number is the reprint of the old Fraser's Catalogue, really written by Nuttall, often referred to, and very inaccessible. American botanists will thank Professor Greene for this valuable addition to their reference libraries. A prominent contribution is that concerning some genera of Rafinesque. It would be a wonderful relief if botanists could be certain once for all just what genera Rafinesque is entitled to. Some 14 or so are recognized in Gray's Manual, and Professor Greene thinks the number will eventually be almost doubled. He presents the following results of his bibliographical investigations: *Shepherdia* Nutt.= *Lepargyraea* Raf.; *Maclura* Nutt.= *Ioxylon* Raf.; *Downingia* Torr.= *Bolelia* Raf.; *Echinocystis* T. & G. and *Megarrhiza* Wats.= *Micrampelis* Raf.; *Stephanomeria* Nutt.= *Ptiloria* Raf. Of course these conclusions are accompanied by a presentation and naming of all the species. The North American species of the genus *Lotus* (= *Hosackia*) are presented, to the number of 54. The part closes with a revision of the genus *Diplacus* Nutt., a genus including a few species usually referred to *Mimulus*.

MR. THEODOR HOLM, of the U. S. National Museum, has long been studying the underground structures of plants, a very much neglected study. In a paper (reprinted from the January number of the *Bull. Torr. Bot. Club*, pp. 1–11) he contributes some very interesting information concerning Uvularia, Oakesia, Dicentra and Krigia. The descriptions are elucidated by three excellent plates.

OPEN LETTERS.

Last words on "biology."

I had thought that botanists were a gentle folk, but in the late numbers of the GAZETTE I have been treated in the same manner as they treat their plants — pulled to pieces. One accuses me of missing the whole point in question, while the other charges me with all the sins in the philological and metaphysical decalogues.

I have received no little information (or misinformation) from these two articles, but the point I made has been ignored.

The question in my mind resolves itself merely into this. Can a man teach biology without teaching the whole of the subject? Can he teach mathematics, unless he teach both arithmetic and quaternions? Can he teach modern languages unless he teach the whole 961 tongues? I claim that he can, and, words aside, this was the whole contention of my previous letter.

If a college or university is in position to give a well rounded biological education it is certainly its duty to do so, and I, as heartily as any one else, can find fault for short-comings in this respect. But if the institution be limited neither botanist nor zoologist should find fault because the biological training has a distinct trend towards either animals or plants, so long as it has a distinctly *biological* character, and it will have such a character if it regards its materials as a part of the living world. For the comfort of my critics I may add that the reason why the majority of such biological chairs are filled with animal biologists is because such have had on the whole the better training.— * * *

Pocket edition of Gray's Manual.

An announcement just made by the American Book Company, publishers of Gray's botanies, possesses unusual interest for botanists. It is of a special edition of the Manual "in small and compact form for satchel use." This is to be printed on thin French paper with narrow margins, so as to make it small and thin. It will be bound in full leather, limp, and cut flush, very much like a foreign guide book. The binding is to be on parchment strips such as are used in the best English prayer books, and the book is intended to stand rough usage. To many it will be a matter of sincere congratulation, that we are to have the indispensable "Manual" in field form. Its issue may be looked to with interest, since it is to be sold at the moderate price of two dollars.— Aug. D. Selby, *Columbus, Ohio.*

NOTES AND NEWS.

Dr. C. F. Millspaugh, in *Zoe* (Jan.), describes two new Euphorbias from Lower California.

The *Annals of Botany* proposes hereafter to give considerable prominence to systematic botany.

It is reported that Pachystima Canbyi is in successful cultivation in the public gardens of Münden, Germany.

Mr. F. W. Anderson is drawing the 60 plates to illustrate Mrs. E. G. Britton's Handbook of Mosses of N. E. America, which is in preparation.

Mr. Hemsley's place in the Kew Herbarium, left vacant by his promotion, has been filled by the appointment of Dr. Otto Stapf, of Vienna.

A CONVENIENT KEY to the genera and species of British mosses is published (with a plate) by Rev. H. G. Jameson in the last *Journal of Botany* (Feb.).

MR. F. H. KNOWLTON, of the U. S. Geol. Survey, has published an account of fossil woods and lignites from Arkansas. Two new conifers (Cupressinoxylon) and two new dicotyls (Laurinoxylon) are described and figured.

IN THE *Philadelphia Public Ledger* of Jan. 20, Mr. Thomas Meehan publishes an interesting account of an almost forgotten botanist, Mathias Kin, a man well know to Muhlenberg and Collins, and about whom Dr. Asa Gray wrote that his history should be worked up by Philadelphia botanists.

IN AN INAUGURAL dissertation at Erlangen, Georg Schneider shows that the "wax" of Myrica cerifera is more nearly allied to the fats than to the wax-like bodies. It consists chiefly of palmatin (70 per cent.) myristin (8 per cent.) and lauric acid (4.7 per cent., mostly free), to form which 9.4 per cent. of glycerin is combined with the corresponding fatty acids.

SOME ACCOUNT of the occurrence and life history of the clover rust (*Uromyces Trifolii* Wint.) has been published by Miss J. K. Howell, (Bull. Cornell Exper. Station, No. 24). The uredo stage was produced upon both red and white clover plants by artificial sowing of the æcidiospores. Attempts to germinate the teleutospores in the spring unexpectedly proved quite fruitless.

DR. JOSEPH BOEHM has at least the merit of consistency in the framing of his theory of transpiring plants. It follows, he says to the Royal Botanical Society of Vienna,[1] since capillarity is the cause of the absorption and ascent of water in transpiring plants, that under certain conditions the transpiration stream may be reversed, so that water must escape from the plant into the ground!

IN THE last *Bulletin of the Torrey Botanical Club* (Feb.) Dr. Morong gives an interesting account of the flora of the desert of Atacama. In the same number Dr. Britton describes six new plants from Dr. Rusby's S. American collection, belonging to the following genera: Begonia, Hariota, Hydrocotyle, Arracacia, Sciadophyllum, and Oreopanax; and Mrs. Britton describes and figures two new Idaho mosses, a Grimmia and a Bryum.

THE PRODUCT of marketable shoots of asparagus is found by W. J. Green (Bull. Ohio Exper. Station, iii, p. 241) to be fifty per cent greater from male plants than from female plants. Preliminary tests were made in 1889, and more complete tests in 1890. During the latter year 50 plants of each kind were used. The difference in vigor is ascribed to the exhaustive effect of seed bearing in the female plants, which is absent in the male plants.

PROF. DR. F. B. POWER and Mr. J. Cambier have recently examined chemically two of the best known "loco-weeds," Astragalus mollissimus and Crotalaria sagittalis. They close their paper in *Pharm. Rund-*

[1] Bot Centralb. xliv, 355

schau (Jan.) by saying: "These results have afforded us the conviction that both the Astragalus and the Crotalaria contain very small amounts of toxic alkaloids, to which we believe the symptoms of poisoning produced by these plants may reasonably be attributed.

IT IS WELL established that the ovules of the higher plants are homologous with the sporangia of vascular cryptogams. The sporangia in the latter are produced on leaf-structures—the sporophylls. In the Angiosperms the question of their origin is unsettled. Goebel investigated a considerable number of doubtful cases. His results are confirmed and extended by Schaefer[1] who finds that in all cases the placenta develops as a part of the carpel and not in the axil of the carpel.

MR. CHARLES ROBERTSON has continued his interesting series of observations on flowers and insects by publishing the *Umbelliferæ* in *Trans. St. Louis Acad. Sci.* (vol. v, no. 3). The group is so uniform in flower-structure, and the species bloom so continuously through the growing season, that they are specially favorable for investigation concerning the effect of time of blooming on the character of the visitors. In his general review of the order Mr. Robertson draws some very interesting conclusions, which are too numerous and specific to be enumerated here.

THE REPORT of the botanist of the Department of Agriculture for 1890 will show that the following collectors have been at work during the year in unexplored or interesting regions: Dr. Edward Palmer in Lower California, Western Mexico, and Arizona; Mr. G. C. Nealley in Western Texas; Mr. J. H. Simpson in the region about Manatee, Florida; and Mr. C. R. Orcutt in the Colorado Desert of Southern California. All these collections either have been or will be reported upon in the new series of "Contributions" now being issued by the National Herbarium.

IN THE *Amer. Chem. Jour.* (xiii, 1) Dr. H. W. Wiley gives an account of "pine-tree honey-dew" and "pine-tree honey." His conclusion is that the "honey-like exudation of the pine tree differs in a marked degree from the honeys of ordinary plants in being right-handed, from a polariscopic point of view, and containing bodies not sucrose nor invert sugar, with a specific rotatory power of about 105." Honey made from this pine-exudation is naturally right-handed, a character as yet observed to be possessed by no genuine honey collected in this country.

HERETOFORE no cells have been recognized in the vascular bundles of the Gymnosperms, which were either the anatomical or physiological representatives of the "companion-cells" of the sieve-tubes. Strasburger, however, now considers the parenchyma cells, rich in protoplasm, which surround the sieve-tubes or are distributed between them as the physiological equivalents of the companion cells. These cells stand in intimate physiological and anatomical relations with the sieve tissue, by means of pits.—Cf. Sitz. d. königl. Preuss. Akad. d. Wiss. zu Berlin. 1890. xiii.—Abstr. in Bot. Cent. xliv. 192.

[1] Flora. 1890, heft 1, *fide* Bot. Cent. xliv, 368.

F. LUDWIG finds in the Synchytrium-galls on Anemone nemorosa a red coloring matter, readily soluble in water, whose identity with anthocyanin he has established. It is a derivative of tannin. He raises the question as to its significance—whether it is a purely pathological product, or whether it serves as a protection to the fungus against snails. He points out the general red coloration and abundance of tannin in insect galls and reminds his readers of Stahl's researches which show the avoidance of tannin-bearing plants by snails. —Cf. Verh. bot. Ver. d. Prov. Brand. xxxi. p. vii, and Bot. Cent. xliv. 82.

THREE NEW methods of preparing aleurone grains of Ricinus are as follows: 1. The Overton method.[1] After hardening sections for several hours in absolute alcohol, immerse them in an aqueous solution of gallotannic acid. The crystalloids absorb the acid and become brownish on treatment with 1 per cent. osmic acid. After washing in distilled water place in glycerine. 2. Poulsen's methods.[2] (*a*) Harden in absolute alcohol 24 hours; place for an hour in a 25 per cent. aqueous solution of tannic acid; wash in distilled water; place in an aqueous solution of bichromate of potassium and allow to remain until brown. Wash and preserve in glycerine. (*b*) Treat as in (*a*) but use a 10 - 20 per cent. aqueous solution of sulphate of iron (which results in a deep blue coloration), wash, dehydrate, clear with clove oil and mount in balsam.

PFEFFER criticizes the conclusions of Hugo de Vries and his pupils as to the origin of vacuoles and the plasma membranes of the cell. (For these views see notes in this journal, xiv. 24, 137.) Pfeffer however affirms[3] that he has been able to produce vacuoles artificially in the plasmodium of Chondrioderma difforme by causing it to enclose solid particles of various soluble substances. The artificial vacuoles were in no wise distinguishable from the true. He also observed the division and fusion of these vacuoles, as well as their fusion with a pulsating vacuole. In some cases they even showed a slight pulsation themselves. His criticisms on the existence, origin and significance of the membrane surrounding the plasma and the membrane enclosing the vacuole are equally radical. A clear insight into these structures seems not yet reached.

THE PRESS, a daily paper of Christchurch, New Zealand, bearing date of Jan. 16, has just been received, giving account of the opening sessions of the other A. A. A. S., the Australasian Association for the Advancement of Science. The sessions began January 15, at Christchurch, in Canterbury College, with the distinguished botanist Baron von Mueller in the chair as retiring president. The proceedings are reported in full, and the whole affair seems full of an energy and spirit which augur well for the future of the younger A. A. A. S. It will be remembered that at the Indianapolis meeting of the American Association the retiring President, Dr. Geo. L. Goodale, was appointed as

[1] Cf. Bot. Cent. xliv. 1 (1890). [2] Rev. gen. de Botanique, ii, 547.
[3] Abhand. d. Math.-Phys. Class d. Sachs. Gesells. d. Wiss. xvi, p. 185—345. —Abstr. in Bot. Cent. xliv. 180.

representative to the Australasian Association. The New Zealand paper gives an account of his cordial reception by the association, and his address in reply. An interview with Prof. Goodale is also printed, in which he gives the Australasians much information concerning science in America, the American Association, and Harvard University. Prof. Goodale is travelling chiefly in the interests of the new Botanical Museum at Cambridge, and will return home by way of Java, China, and Japan.

THE PHYSIOLOGICAL significance of calcic oxalate according to Dr. G. F. Kohl[1] lies in the fact that the oxalic acid and its congeners are by-products in the synthesis of proteids from amides and carbohydrates. If this is true oxalic acid and its salts ought to occur in all plants. While however calcic oxalate in the higher plants is very wide-spread, in the thallophytes it is strikingly rare. Kohl shows that nevertheless oxalic acid is abundantly produced by both fungi and algæ, and that it will readily combine with calcium when under proper conidtions. The production of oxalic acid by the recently described Saccharomyces Hansenii has been designated as oxalic acid fermentation which is reckoned as one of the oxidative fermentations, in contrast to the splitting fermentations. Fermentation is in all cases, he says, nothing but a nutritive process of the ferment-inducing organism, with its consequences. Colorless organisms must decompose—*ferment*—carbohydrates, alcohols, etc., obtained from without; color-bearing and therefore mostly CO_2-assimilating organisms on the contrary decompose—*ferment*—self-formed carbohydrates, etc. Logically we must say: *all plants are fermenting agents;* for if we call the formation of oxalic acid by a fungus "oxalic-acid fermentation" we must extend this designation to all plants in which the formation of oxalic acid occurs. We can arrange plants in two series according to the main product of the fermentation, the first including those which induce oxidative fermentations, the second including the agents of splitting fermentations.

Plants.	*Oxidative fermentation.*	*Splitting fermentation.*
Schizomycetes	acetic acid	Alcohol, lactic acid, butyric acid.
Numerous other fungi	oxalic acid carbonic acid	Alcohol.
Algæ	oxalic acid carbonic acid	———
Bryophytes, Pteridophytes, Phanerogams.	carbonic acid oxalic acid tartaric acid malic acid	———

The lower plants thus induce chiefly splitting fermentations, the higher exclusively oxidative.

[1] Bot. Centralb. xliv. 337.

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